Quality Improvement of an Assembly Line using Industrial Engineering and Operations Management Techniques-A systematic approach

Md. Atikul Islam
First Senior Assistant Director
Walton Micro-Tech Corporation
Chandra, Kaliakoir, Gazipur, Bangladesh
atikiem@gmail.com

Md. Sunny Ul Islam
Deputy Director
Walton Micro-Tech Corporation
Chandra, Kaliakoir, Gazipur, Bangladesh
Sun_kuet@yahoo.com

Jiku Das Gupta
First Senior Assistant Director
Walton Micro-Tech Corporation
Chandra, Kaliakoir, Gazipur, Bangladesh
jikuiem@yahoo.com

Abstract

Every business organization always wants to provide quality products and services to their customers which are made up through a sequence of operations, which themselves have, specific and defined levels of quality. To achieve the optimum quality level, there must be a visible and dedicated quality control and quality assurance system so that quality standards are maintained in all levels and sections. To establish such system first need to identify the key areas, which not only affect quality standards, but also impacts on delivery schedules and overall costs. Using proper system those key area bottlenecks need to be solved through analyzing by the sourcing, research and development, production, quality and production support teams. This research paper includes the systematic approach do develop a standard quality management system through which the major quality parameters are set and quality levels are achieved through developing man, machine, materials, control systems etc. A case study was taken of three sewing lines of a reputed garment industry and quality level increased by setting quality control system, improving bottleneck quality points one by one, analysis of costs and benefits by the implementation of this system.

Keywords
Quality Control (QC), Quality Assurance (QA), Quality Management System, Bottleneck, Optimum Quality Level.

1. Introduction

The desired quality level of a product will depend on the objectives and policies of the company and as well as capacities and skills of the employees. Since most of the production systems employed in assembly factories includes the batch system which includes a system whereby the products are gradually assembled as they move through successive sub-assembly and main assembly operations. The principles of this system are: The various

sections are positioned according to main operation sequence, with each section having a layout according to the sequence of operations required to produce a particular component.

To achieve desired quality level the objectives or goals of the company need to set first against quality. An effective quality goal or objective could be, to be the best company in this sector and its policy should be to deliver Total Quality Goods and services to all customers. This could be accomplished by means of the following actions:

1. Strive to satisfy and to exceed customers' expectations to be accurate and on time with all deliverables.
2. Focuses on continual improvement in all quality related activities and seek to prevent errors and eliminate the root causes of problems.
3. Develop and maintain mutually beneficial relationships with suppliers to assure a stable supply of quality materials and services.
4. Maintain competitive prices and superior financial performance by eliminating waste wherever it occurs.

In order to achieve quality in the completed product the raw materials quality need to ensure first. Otherwise the whole system will not be effective. After that the whole assembly process quality need to define and standardize and quality awareness need to establish among all the employees related with it. The monitoring of the quality standard maintenance need to establish in such a way that every product passes from one operation to another operation provides desired quality level. This is mandatory in all kinds of assembly line because without ensuring quality in all process/operation this is very difficult to ensure quality product at the end.

In some cases, this is very effective to ensure first time quality, which means each process need to deliver quality product at one operation only. Any kind of repairing is not allowed because it not only affect the standard of quality it also increase cost of manufacturing and high amount of rejection occurs. This is only possible by using automated process or applying work aids, jigs, fixtures etc. To ensure quality most of the recognized industries uses own machine making and maintenance teams so that they can easily develop customized machineries, equipment's according to demand. Sometimes customized machines not only provide quality products but also provide high productivity. To achieve optimum quality level skill of the employees is very necessary so that they can understand the functioning of the machine set ups in which they can produce quality product.

Many companies have established training centres to train their employees to the required level and without certification by the trainer they can't put in an assembly line. The maintenance team also plays a vital role for maintaining desired quality level through providing accurate machine set ups according to demand.

2. Literature Review

Waste is generally caused due to unnecessary delays, processes, costs and errors. The seven types of wastes associated with Lean are overproduction, transportation, processing, inventory (work-in-process and finished goods), waiting, motion and defects. These wastes are also associated with support functions involved in a production system. The main focus of Lean is to address the value-added and non-value added activities. A non-value added activity (NVA) is most commonly defined as any activity for which the customer is not willing to pay. Lean necessitates the reduction of these NVA"s by making the system perform better while consuming lesser resources. Some of the widely-recognized benefits of Lean manufacturing include:

- Productivity Improvement.
- Reduced production lead times.
- Reduced inventory (Work-in-process and finished goods).
- Quality Improvement.
- Better utilization.
- Organized work flow and
- Safer operations.

Since its introduction to manufacturing, the concept of Lean with its fascinating principles has become a dominant strategy in managing the production systems (Womack and Jones, 1990). Shah and Ward (2003) explore the concept of Lean manufacturing and summarize that most of the modern manufacturing practices commonly associated with Lean production show strong operational performance. Implementing each of the Lean practices such as Continuous

Improvement (Kaizen), Cycle time reduction, Pull System (Kanban), bottle neck removal, JIT, etc. contribute largely to the operating performance of a production system.

Today's market environment demands for high quality products with low costs with a greater variety in products and at faster response times. The manufacturer faces the challenge to meet these demands while maintaining a profit. Implementing Lean is an ongoing and long term goal. Proper defining of the goals suitable to a production process and setting baselines is the key to productivity improvement.

3. Methodology

To improve quality of the analyzed assembly lines a step by step method applied so that the improvement becomes a systematic approach and very easy to understand and implement. A case study was taken of three assembly line of a reputed garment industry where long sleeve shirts were manufactured through assembly operation including 52 sewing machines of different types and total 74 peoples were involved with the assembly operation each line. The systematic approach has been discussed in small segments through brainstorming stage and step by step action plans.

3.1 Orientation Meeting

To implement quality improvement a small discussion meeting has been arranged with the production supervisors, quality supervisors, production support team, sourcing, production and quality manager, general manager. The overall objective of the quality improvement project explained to everyone and their valuable suggestions were taken with high priority from everyone's end.

3.2 Defining Quality Standard

The whole assembly process at first divided into several segments. The long sleeve shirt assembly process was divided into the following small segments.

i. Collar making
ii. Cuff making
iii. Sleeve making
iv. Pocket making
v. Front part making
vi. Back part making
vii. Final assembly of the shirt

In all small segments the upcoming quality faults were carefully identified and every section a quality control table inserted in such a way that all small completed parts come through quality pass and ensures desired quality. A standard format has been developed showing all quality faults and given to the respective quality checkers in such a way that anyone can check the faults coming and take initiative to solve the problems easily.

The quality checker table was provided with adequate lights, required measurement tapes with properly calibrated and some patterns made by hard paper also provided so that they can easily check and identify problems. The given quality standard was checked by all production, quality, sourcing, production support and maintenance team members.

3.3 Training to the Quality Inspectors

A training session was arranged with all the quality inspectors explaining the objectives, involvement required, checking points, allowances, how to solve upcoming faults, necessary preventive and corrective actions. Each and every morning a small counseling was done by the quality inspectors before starting works to all the operators and helpers involved with the processes. The acceptance level of quality all time highlighted and necessary motivation was given to them on a regular basis.

3.4 Summarizing the Quality Reports

Every hour of production the quality inspection sheet was checked by the supervisors and managers and highlighted faults was explained properly. The necessary preventive and corrective actions were taken immediately by respective section supervisor and necessary maintenance support were given on time. End of the day the completed quality inspection sheet was given to the production support and industrial engineering team for analysis.

3.5 Development Initiative and Priority

After analyzing weekly and monthly basis reports some development priorities were set for development depending on the impact on the production and quality effects.

3.6 Action Plan

After finalizing the development area an action plan was set with appropriate deadlines and responsible persons so that everyone clearly understood their responsibility.

3.7 Monitoring

After successful implementation, a monitoring system was introduced so that the whole system can be monitored properly.

4. Research and Findings of the Study

The quality improvement project implemented required few additional investment in manpower. But the effectiveness and after successful implementation the outcomes were tremendous development in production increase, repair, productivity and finally quality. During implementation of the quality improvement plan a step by step priority was set depending on the productivity. One whole month's quality inspection report has been analyzed and shown in Table 1.

Table 1: April 01 to April 30 Defects (AQL)

Defect Description	Line-06	Defect %	Line-07	Defect %	Line-08	Defect %
Broken Stitch	85	11.3%	85	11.87%	90	11.04%
Skip Stitch	67	8.9%	36	5.03%	38	4.66%
Down Stitch	85	11.3%	61	8.52%	88	10.80%
Raw Edge	**123**	16.3%	62	8.66%	81	9.94%
Hi low	10	1.3%	1	0.14%	1	0.12%
Thread Tension	8	1.1%	0	0.00%	0	0.00%
Puckering	0	0.0%	0	0.00%	3	0.37%
Uneven Shape	37	4.9%	4	0.56%	14	1.72%
Up-Down Position	11	1.5%	7	0.98%	0	0.00%
Holes/Damages	11	1.5%	5	0.70%	9	1.10%
Poor Ironing	0	0.0%	0	0.00%	1	0.12%
Stain/Oil Stain	4	0.5%	31	4.33%	5	0.61%
Open Seam	2	0.3%	2	0.28%	0	0.00%
Slanted	0	0.0%	0	0.00%	2	0.25%
Misplace Button	0	0.0%	0	0.00%	0	0.00%
Pleat	76	10.1%	57	7.96%	80	9.82%

Projection	1	0.1%	0	0.00%	0	0.00%
Uncut thread	**122**	16.2%	**216**	30.17%	**265**	32.52%
Others	112	14.9%	149	20.81%	138	16.93%
Total	**754**		**716**		**815**	
Inspected Qty	6150		6160		6160	
Defect %	**12.26%**		**11.62%**		**13.23%**	

To initiate development the major and minor defects were summarized and firstly major defects were taken for analysis and improvement. Table 2 shows the major defects which are taken for first development.

Table 2: Major defects for improvement

Major Defects	Line-06	Line-07	Line-08	Total	% of Total Defects	% of Total Inspected
Broken Stitch	85	85	90	260	12.29%	1.41%
Skip Stitch	67	36	38	141	6.66%	0.76%
Raw edge	121	62	81	266	12.57%	1.44%
Un cut thread	122	216	265	603	28.50%	3.26%
Down stitch	85	61	88	234	11.06%	1.27%
Pleat	76	57	80	213	10.07%	1.15%
Other	112	149	138	399	18.86%	2.16%
Total Defects	**670**	**666**	**780**	**2116**	11.46%	
Total Inspected	**6150**	**6160**	**6160**	**18470**		

High Impact

The major defects found from the line were broken stitch around 12.29% which is mainly occurs due to improper machine adjustment, wrong needle selection, thread strength and elasticity problems. An immediate meeting was called with all the mechanics and maintenance in-charge for proper machine adjustment and after discussing with the supplier the needle was changed so that broken stitch faults removes. After proper adjustment, the faults coming below 0.5% from 12.29%.

The second major defect found was skip stitch which is also a result of improper machine adjustment and wrong thread selection. After discussing with the buyer, the thread changed and the defects was negligible.

Raw edges were mainly coming due to improper blade adjustment and sharpness of overlock machines. After discussing with maintenance team the machine blades were changed at scheduled interval and the faults reduced to minimum.

The uncut threads were mainly coming due to lack of auto trimmers at single needle and double needle lock stitch machines. After inserting auto trimmer machines the uncut threads were reduced to below 0.3% and in some cases of feed of the arm machines the extra thread were managed through the helpers working with the machine.

Down stitch and Pleat defects were solved with the machine adjustment and speed control of the stitching.

Before starting for development, the impact level also analyzed and has shown in Table 3. The high impact, medium impact and lower impact has shown to all quality inspectors and operators using color code so that everyone can see who is doing maximum defects and monitoring from all sections can be taken as required.

	Medium Impact
	Low Impact

Table 3: Impact level

Major Defects	Line-06	Line-07	Line-08	Total	% of Total Defects	% of Total Inspected
Broken Stitch	85	85	90	260	12.29%	1.41%
Skip Stitch	67	36	38	141	6.66%	0.76%
Raw edge	121	62	81	266	12.57%	1.44%
Un cut thread	**122**	**216**	**265**	603	28.50%	3.26%
Down stitch	85	61	88	234	11.06%	1.27%
Total Defects	**670**	**666**	**780**	**2116**		
Total Inspected	**6150**	**6160**	**6160**	**18470**		

Depending on the impact level at first a target was set for reducing the defects. Different targets were set for different types of defects. For example, the broken stitch, skip stitch, raw edge and down stitch target was set 50% reduction within one week because it was required about 32 machines proper adjustment depending on different defects. Buyer recommendation and decisions were required for changing needle and thread type. For un cut thread the target was set for 100% within 1 week because it was required only auto trimmer setup in all the single and double needle lock stitch machines which can be easily done by in-house maintenance support.

Based on the targets for reducing defects an effective action plan was setup with appropriate deadline and responsible person for defined responsibility. The major responsibility included the production managers, quality managers and general managers also so that everyone takes the full responsibility and necessary controls could be taken from top management to middle management. For all three lines, respective supervisors were mainly responsible for coordination with operators, mechanics and quality inspectors.

Table 4: Action Plans

SL#	Description	Who	When	Status
1	**Awareness relevant Supervisors/Mechanics & In-charges**	Hasitha/Damith/Alaudin	18-Apr	
2	**0% Uncut Thread**	IE Team	15-May	
	a) Fix the thread standard based on the Bulletin.	Hyder		
	b)Make sure UBT/Wiper function works properly.	Bilal/		
	c) Audit and update the status of UBT function.	Atik/Kamrul		
	d) Implement Weekly Audit System for machine condition.	Atik		
	d) Check & update daily basis operators wise UBT/Wiper Usage.	Hyder		
	g) Implement daily audit system for uncut threads.	Hakim/Kamrul /Hyder		
	f) Implement Vacuum edge cutters for over lock operation.	Hyder/Atik		
3	**50% Broken Stitch Reduction**			
	a) Categorized broken stitches Operation wise	Atik		
	b) Identify the reasons for broken Stitches.	Atik/Hyder		
	c) Make action plan to reduce broken stitches base on the analyzed data.	Atik		
4	**50% Down Stitch Reduction**			
	a) Categorized Down Stitches Operation wise	Atik		
	b) Identify the reasons for Down Stitches.	Atik/Hyder		

	c) Make action plan to reduce Down stitches base on the analyzed data.	Atik		
5	**50% SkipStitch Reduction**			
	a) Categorized Skip stitches Operation & Machine wise	Atik		
	b) Make sure the machine settings which we identified	Hyder/Bilal		
	c) Implement Machine & Operation cheek list for mechanics.	Hyder/Bilal		
	d) Identify the correct needle & thread combination for particular operation.	Kabir / Hasitha/Bandara		

Depending on the action plan the tolerance was changed for different operations after discussing with the respective buyer requirements and final Accepted Quality Level (AQL) was given to the quality inspectors.

Table 5: Operation wise tolerance levels

Line No:

Style: **Date:**

Sl. No.	**Section**	**Operation**	**Machine**	**Maximum Allowable Thread Length**	**Who will Cut Balance Thread**	**Remarks**
1	Collar	Make collar by Jig mc -manual	1N2TLS-UBT			
2	Collar	Trim Collar Round	1N3TOL			
3	Collar	T/S Collar 1/4"	1N2TLS-PL			
4	Collar	Collar Band Hem With Lining	1N2TLS-PL			
5	Collar	Set band to collar	1N2TLS-EC			
6	Collar	Mid line top st at band	1N2TLS-PL			

For reducing the uncut and extra threads by 100% an additional responsibility given to the top personnel to check and audit two garments every day and check the actual reasons for extra threads as shown in Table 6. A standard form/checklist shown in Table 7 developed for reduction of defects

Table 6: Uncut & extra thread checking

SL. No.	**Tasks**	**Responsible Person**
1	Audit two garments every day by IE & Top Management. The Schedule for auditing …. a) IE Manager (Saturday) b) Production GM (Sunday) c) Production AGM (Monday) d) Quality Manager (Tuesday) e) COO (Wednesday) f) Merchandizing Manager (Thursday)	

Table 7: Format/Checklist for extra/uncut thread

Line No:

Style: **Date:**

Sl. No.	Section	Operation	Machine	UBT/Non UBT	Audit First Gmt.	Audit Second Gmt.	Operator Name/ID	Signature	Remarks
1	Collar	Make collar by Jig mc -manual	1N2TLS-UBT						
2	Collar	Trim Collar Round	1N3TOL						
3	Collar	T/S Collar 1/4"	1N2TLS-PL						
4	Collar	Collar Band Hem With Lining	1N2TLS-PL						
5	Collar	Set band to collar	1N2TLS-EC						
6	Collar	Mid line top st at band	1N2TLS-PL						
7	Collar	Cut excess at btm of band	1N3TOL						
8	Sleeve	Attach Sleeve Tape	1N2TLS-UBT						
9	Sleeve	Tack Sleeve Tape with cut	1N2TLS-UBT						
10	Sleeve	Attach Sleeve Placket	1N2TLS-UBT						
11	Cuff	Hem Cuff with lining	1N2TLS-PL						
12	Cuff	Run Cuff - Square Match	1N2TLS-UBT						
13	Cuff	Trim Cuff	1N3TOL						

After successful implementation of one weeks the defects were reduced to minimum at the first stage which is shown in Table 8. After careful adjustment of all machines and increasing awareness among the operators the all defects were made negligible.

Table 8: Defects after one week

Defect Description	Line-06	Defect %	Line-07	Defect %	Line-08	Defect %
Broken Stitch	42	9.4%	42	11.14%	45	11.22%
Skip Stitch	33	7.3%	18	4.77%	19	4.74%
Down Stitch	42	9.4%	30	7.96%	44	10.97%
Raw Edge	60	13.4%	31	8.22%	40	9.98%
Hi low	10	2.2%	1	0.27%	1	0.25%
Thread Tension	8	1.8%	0	0.00%	0	0.00%

Puckering	0	0.0%	0	0.00%	3	0.75%
Uneven Shape	37	8.2%	4	1.06%	14	3.49%
Up-Down Position	11	2.4%	7	1.86%	0	0.00%
Holes/Damages	11	2.4%	5	1.33%	9	2.24%
Poor Ironing	0	0.0%	0	0.00%	1	0.25%
Stain/Oil Stain	4	0.9%	31	8.22%	5	1.25%
Open Seam	2	0.4%	2	0.53%	0	0.00%
Slanted	0	0.0%	0	0.00%	2	0.50%
Pleat	76	16.9%	56	14.85%	80	19.95%
Projection	1	0.2%	0	0.00%	0	0.00%
Uncut thread	0	0.0%	0	0.00%	0	0.00%
Others	112	24.9%	150	39.79%	138	34.41%
Total	**449**		**377**		**401**	
Inspected Qty	**6150**		**6160**		**6160**	
Defect %	**7.30%**		**6.12%**		**6.51%**	

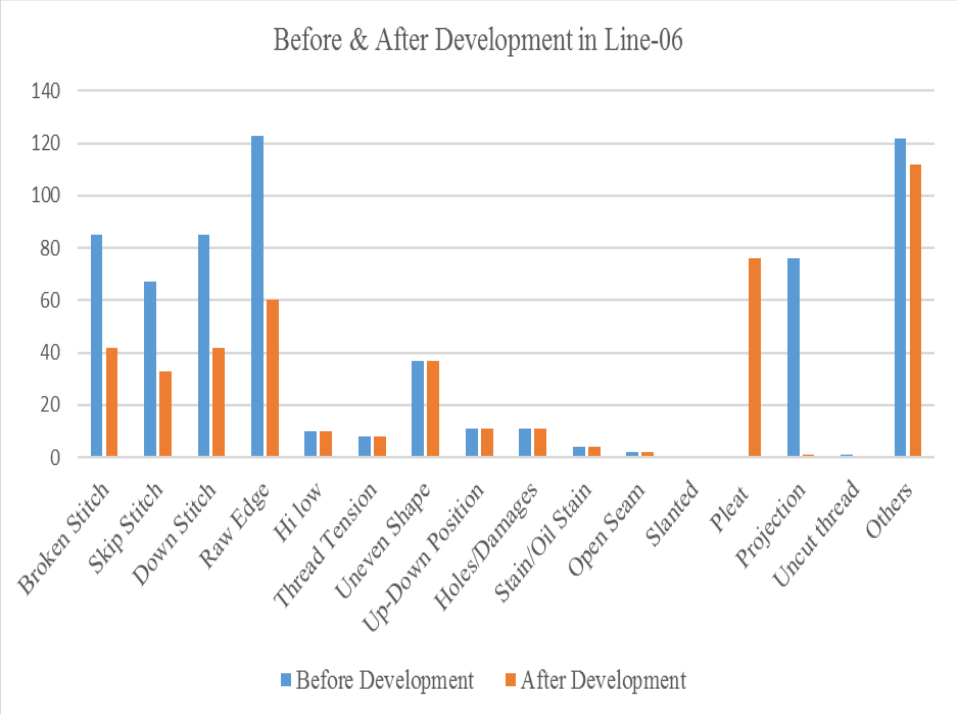

Figure 1. Before & After Development at Line-06

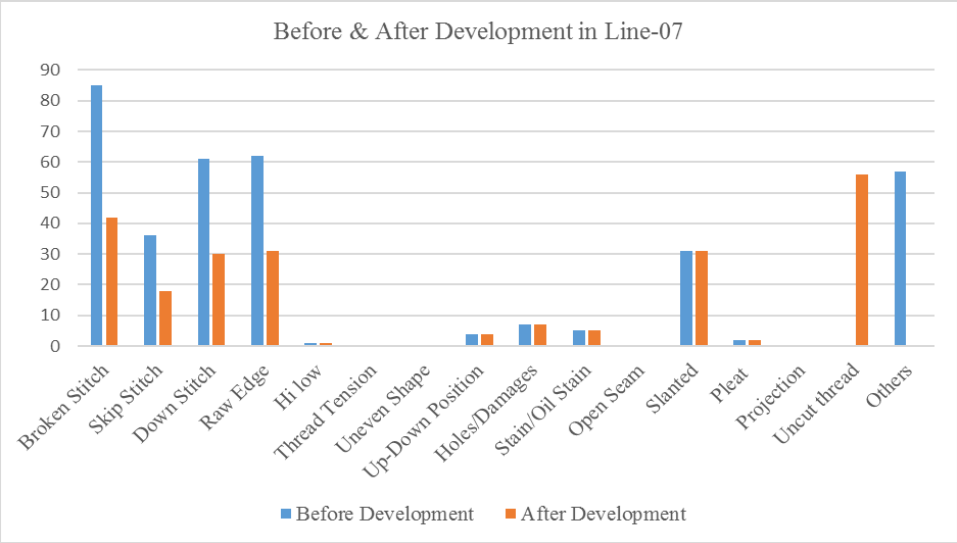

Figure 2. Before & After Development at Line-07

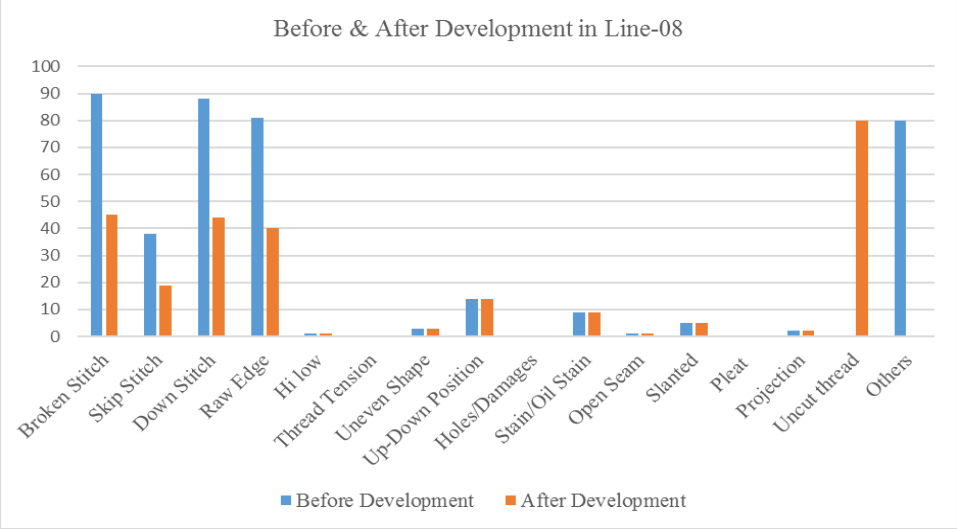

Figure 3. Before & After Development at Line-08

5. Future Recommendation

For all kinds of developments in the above quality improvement project the sewing section only considered. Some measurement problem in the final garment occurred due to some problems in cutting section and desired fabric qualities. In order to maintain quality standard in high level all sections need to analyze and develop so that majority causes of defect can be solved in the initial stages. Based on the quality requirements if the cutting section was developed majority problems could have been solved easily.

In this analysis, the improvement was done only with the existing resources. It was possible to use customized and automated machineries of higher budget for expected quality and productivity. There are so many ungraded machines available for sleeve join, cuff join, collar attach, side seam join, bottom hem, button attach etc. if these machineries could have been used the productivity could have been increased along with quality.

Although a small training session arranged for the operators and supervisors but for machine adjustments the mechanics need special training from the machine supplier so that they can understand the machine adjustments

properly and fix the problems within short time. It would be better for future it these resources could be considered for development.

6. Conclusion

Achieving desired quality is not a single person's task. It requires involvement of everyone from top management to bottom level related to the product from sampling stage to final packing. Awareness among the workers and supervisors regarding quality could bring the best quality because if the quality can be ensured at each stage it will definitely provide the best. With proper machine set up, training and skill development this task would be easier to implement. In the case study, only three lines was developed against quality with available resources and the result grows to rejection rate reduction from 4.7% to 1.2%, daily production increase from 750 pcs to 1070 pcs each line, finishing manpower reduction of 7 persons, on time delivery and mostly the buyer/customer satisfaction. The major improvement occurred in production due to the reduction of rework and due to awareness operator achieving quality in single operation and satisfaction from root level to top management.

Acknowledgements

We are very grateful to Mr. Hasitha Jayeeria (IE Manager) and Mr. Damith Fernando (GM Production) of the company for giving us the opportunity to work with the quality improvement project and for giving us the tremendous support in learning about quality and quality improvement system. We are also grateful to all workers in the three lines for giving the support about achieving the desired targets daily and also to the quality section which helped us a lot to take all kinds of preventive actions to be done and achieving desired quality. It would not be possible without the support from quality department personnel's.

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Biography

Md. Atikul Islam is a First Senior Assistant Director of Walton Micro-Tech Corporation a sister concern of Walton Group. Previously he was worked as Deputy Executive in Industrial Engineering Department of Pearl Garments Company Limited (PGCL) a sister concern of EPIC Group a Hong Kong based Multinational Garment Industry. He earned B.Sc. in Industrial and Production Engineering from Khulna University of Engineering and Technology, Bangladesh. He has published conference papers on International Journals and Conferences on Mechanical, Industrial and Energy Engineering (ICMIEE) in the field of Supply Chain Management and IEEE in the field of Unit Production System. Md. Atikul Islam has done research projects and Undergraduate thesis project with Kazi Badrul Hasan, Assistant Professor of the Department of Industrial Engineering and Management (IEM) of Khulna University of Engineering & Technology (KUET). His research interests include Supply Chain Management, Manufacturing, optimization, Operations Management, Operations Research, and Lean Manufacturing.

Md. Sunny Ul Islam is a Deputy Director of Walton Micro-Tech Corporation a sister concern of Walton Group. Previously he was worked as Deputy Executive in Industrial Engineering Department of Pearl Garments Company Limited (PGCL) a sister concern of EPIC Group a Hong Kong based Multinational Garment Industry. He earned B.Sc. in Industrial and Production Engineering from Khulna University of Engineering and Technology, Bangladesh. His research interests include Supply Chain Management, Manufacturing, optimization, Operations Management, Operations Research, and Lean Manufacturing.

Jiku Das Gupta is a First Senior Assistant Director of Walton Micro-Tech Corporation a sister concern of Walton Group. Previously he was worked as Deputy Executive in Industrial Engineering Department of **ESBL Crystal Group Hong kong**. He earned B.Sc. in Industrial and Production Engineering from Khulna University of Engineering and Technology, Bangladesh. His research interests include Supply Chain Management, Manufacturing, optimization, Operations Management, Operations Research, and Lean Manufacturing.